Proceedings of the Canadian Society for Mechanical Engineering International Congress
Computational Fluid Dynamics Canada International Congress
CSME - CFD-SC2023
May 28-31, 2023, Sherbrooke, QC, Canada

Non-contact, single-sided access ultrasonic guided waves for the assessment of materials mechanical properties

C. Despres[1,2,3], N. Quaegebeur[1], P. Masson[1], M. Castaings[2,3], E. Ducasse[2,3]

[1]Dept Mechanical Engineering, GAUS, Univ. Sherbrooke, Sherbrooke, Québec, Canada
[2]Univ. Bordeaux, CNRS, Bordeaux INP, I2M, UMR 5295, F-33400, Talence, France
[3]Arts et Metiers Institute of Technology, CNRS, Bordeaux INP, Hesam Universite, I2M, UMR 5295, F-33400 Talence, France

ABSTRACT

Research about material characterization without contact has been carried out by many authors using immersion or laser-based ultrasonic techniques. Immersion techniques however imply that the material is not water sensitive and that the sample fits within the immersion tank. Therefore, it is important to develop a characterization process that is suitable for all types of materials, and ideally not requiring access to both sides of the tested specimen, as this is often not possible in industrial context.

The proposed solution operates with guided waves propagating within the test sample, but generated and measured in air, using two transducers located on the same side of the sample. Their dispersive behavior is measured and used to estimate the mechanical properties (for now the Young's modulus and Poisson's ratio of an isotropic material) and the thickness of a plate-like material. Both transducers are simultaneously rotated in order to emit and detect several Lamb modes over a large frequency range. Recorded signals are post-processed to determine the dispersive characteristics and are used as input of the inverse problem to estimate the mechanical properties and the thickness of the sample. Then, the inverse problem is solved using an optimization algorithm based on evolutionary process.

To make sure optimization results are reliable, another set of experimental data obtained with well known linear translation technique and spatial Fourier transform has been used. The comparison between the two results from optimization demonstrates that both techniques give very close results. The presented method allows fast measurement of guided modes without contact and accurate estimation of mechanical properties and thickness. The accurate estimation of property is determined by the ability to measure modes that are sensitive to required properties. A limitation appears with the non-contact method. Since both the emitter and the receiver are non-contact and working in air and since some modes needs more energy than other to be excited, the energy transmitted to the plate can be not sufficient to excite the sensitive modes. This makes that for some material the estimation of all properties isn't possible. Further development to improve the transfer of energy from transducers to the plate and the accuracy of the measurement method is ongoing in order to provide more accurate optimization results and real-time estimation for industrial applications.